

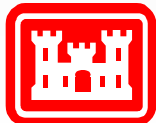
# Novel Corrosion Control Coating Utilizing Carbon Nanotechnology

Susan A. Drozd

U.S. Army Engineer Research and Development Center  
Construction Engineering Research Laboratory

Todd Hawkins

Tesla NanoCoatings Limited



US Army Corps  
of Engineers

Engineer Research & Development Center  
Construction Engineering Research Laboratory

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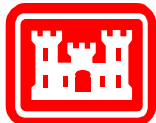
# R&D Goal

**Develop best available & user-friendly coating systems for protecting steel infrastructure from corrosion:**

System #1   3-Coat system  $\geq$  best 3-coat Zn rich system

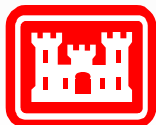
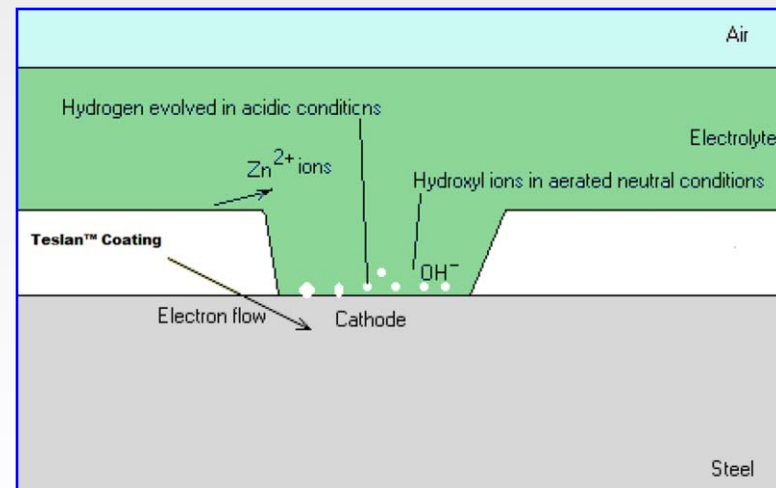
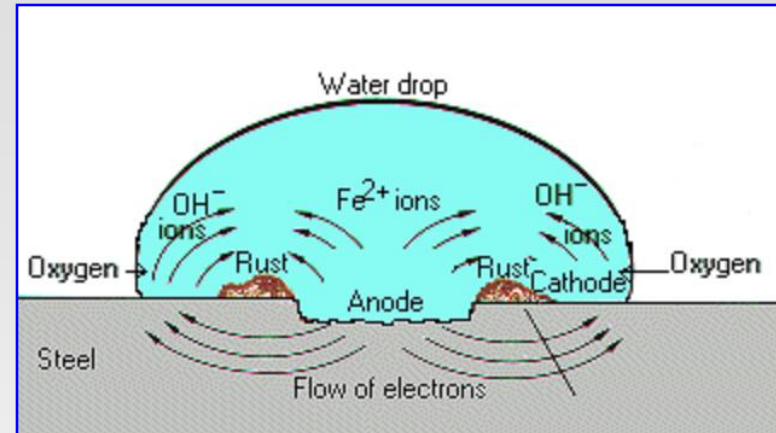
System #2   2-Coat system = best 3-coat Zn rich system

System #3   1-Coat DTM  $>$  best 1-Coat DTM alternative



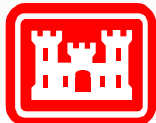
# Novel Epoxy Paint System

- 3-Coat Epoxy Paint System
  - Epoxy primer formulated with
    - Zinc dust
    - Single Wall Carbon Nanotubes (SWNT)
  - Epoxy Intermediate Coat
  - Polyurethane topcoat
- Dual barrier coating and cathodic coating protection for steel
- Shifts the potential to cathodic potential in the event of a coating defect
- Aluminum can be used in place of the zinc



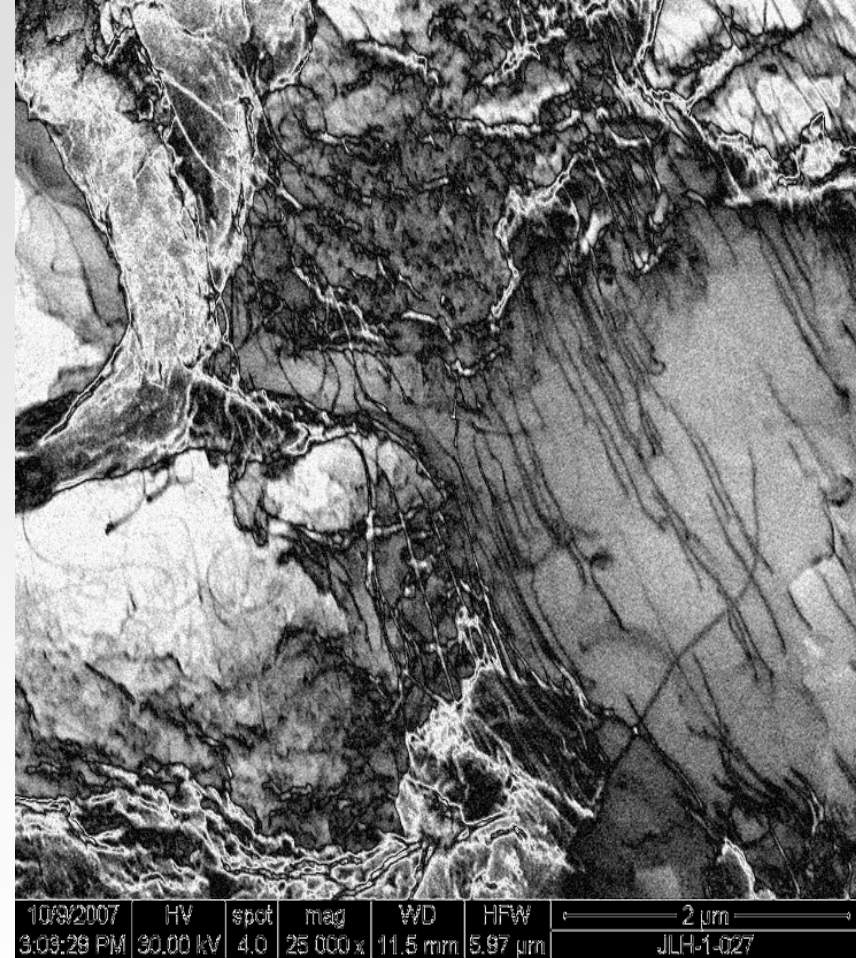
# Dual Purpose Technology

- First, produce the toughest most resilient barrier coating
- Second, shift the potential of the environment to a less corrosive cathodic potential
- Outperforms barrier coating only technology



# Function of Single Wall Carbon Nanotubes (SWNT)

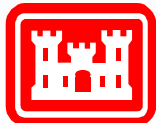
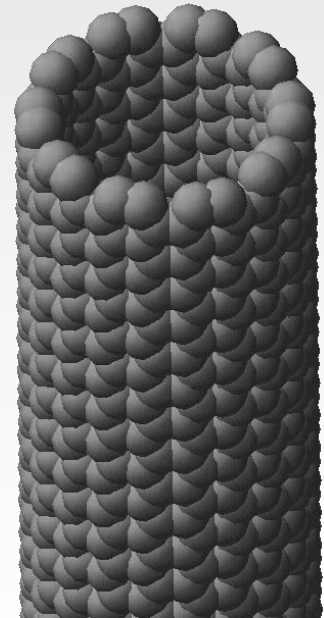
- Produce galvanic reactivity of the substrate
- Facilitate electron transfer through the binder
- Reinforce / Toughen Binder



# How ?

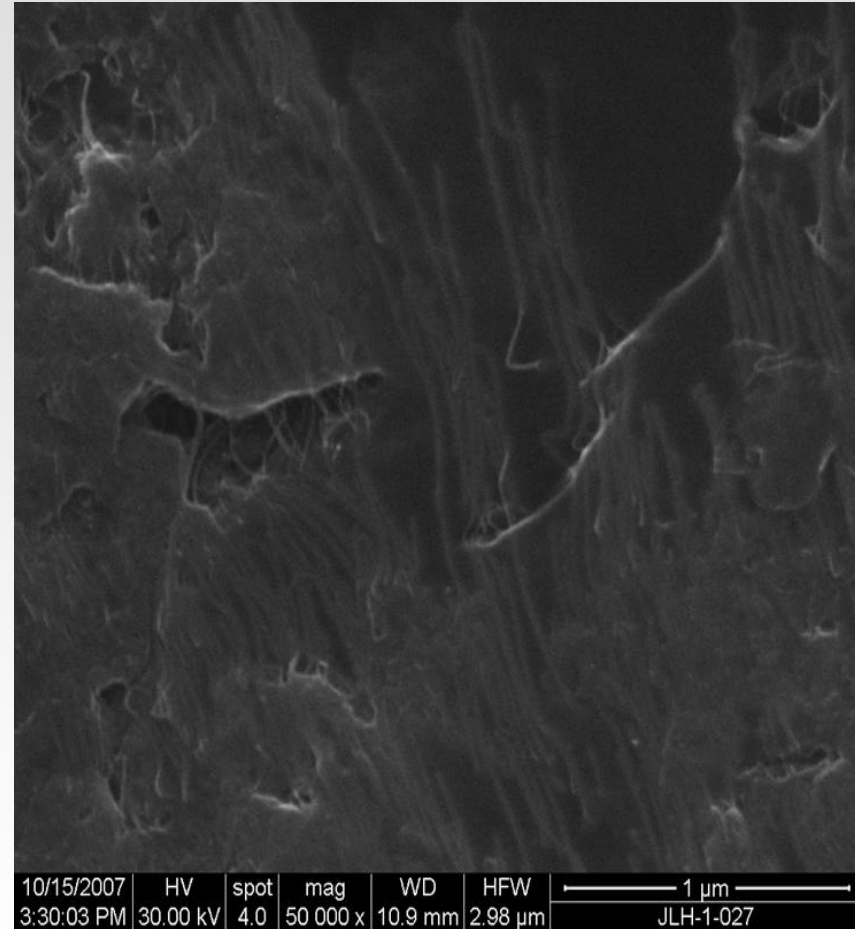
- Pioneered by Nobel Laureate Richard Smalley
- Structure
  - electrical
  - mechanical properties
- Current-carrying capacity
  - 1,000x greater than copper
- Tensile strength
  - 50x greater than steel

Single Walled  
Carbon Nanotube



# Barrier / Electrical Properties

- Carbon Nanotube Ropes
  - strength of the carbon-carbon bonds builds an extended network of Carbon Nanotube Ropes
- Reinforce / Stiffen / Toughen
- Electron Path
  - through the binder
  - between the cathodic substrate and anodic sacrificial metals

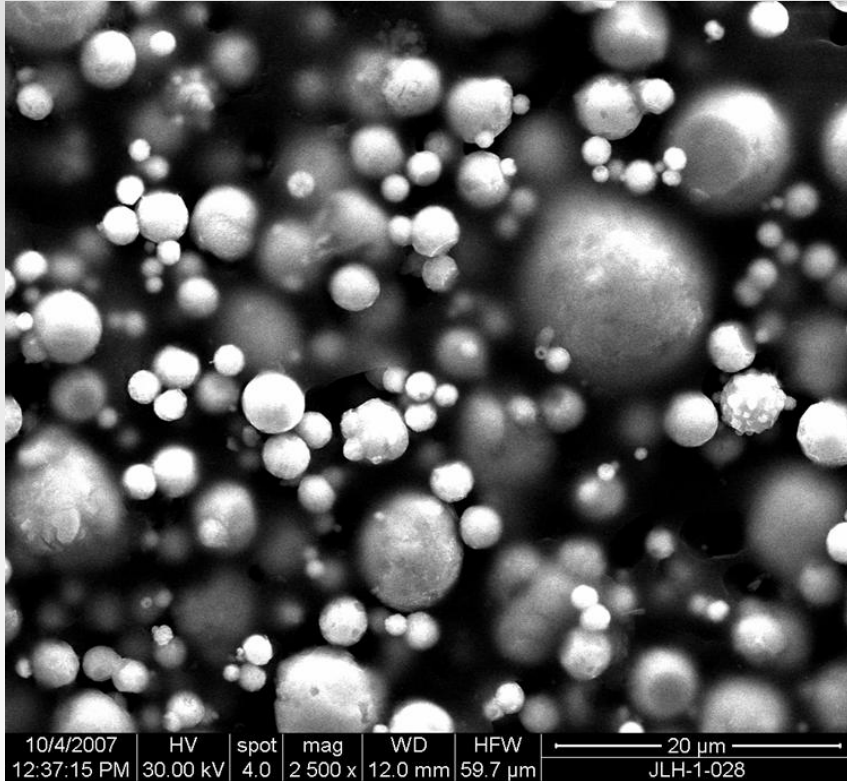


SEM Micrographs courtesy of Unidym, Inc., Houston, Texas

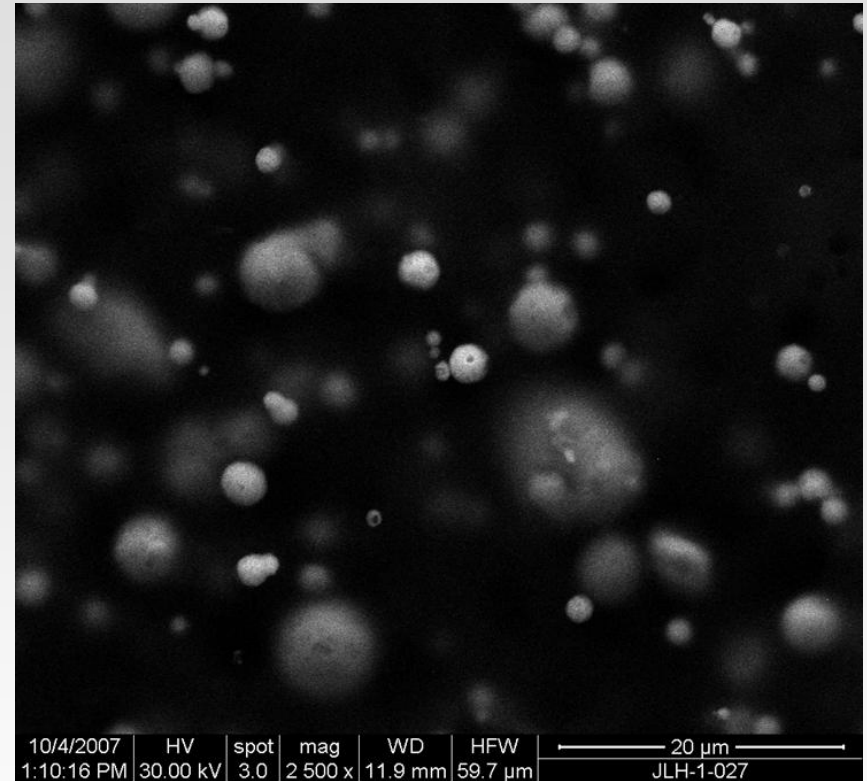




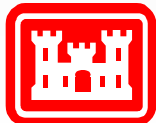
# Barrier Properties



**Traditional Zinc-Rich Primer**



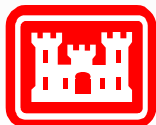
**TESLAN™ Primer**



**Lower Pigment Loading = Better Adhesion & Stronger Film**

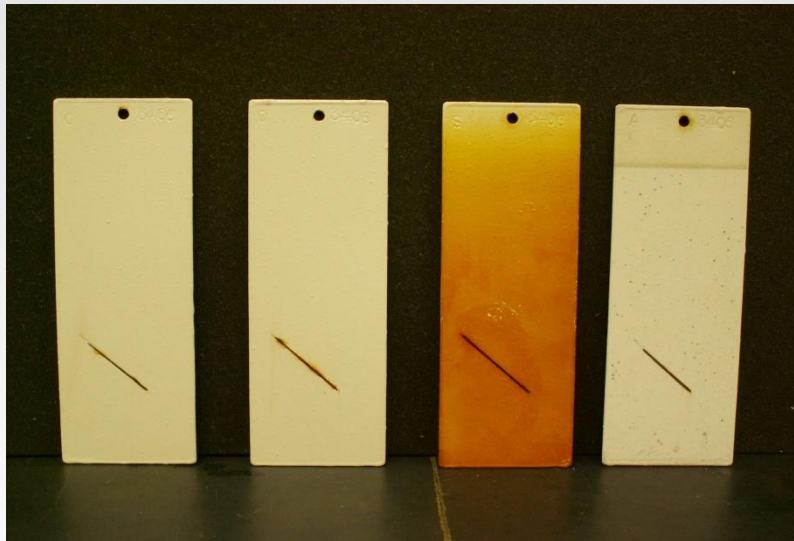
# Corrosion Testing

- Outdoor exposure and weathering - ASTM D1014
- Fresh water immersion testing - ASTM D870
- Salt water immersion testing – ASTM D870

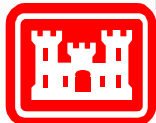


# 3-coat Epoxy System

- Graded “10” of “10” after 3-  
years of testing (25,000+ hours)
  - No undercutting
  - evaluation criterion in accordance with ASTM D1654

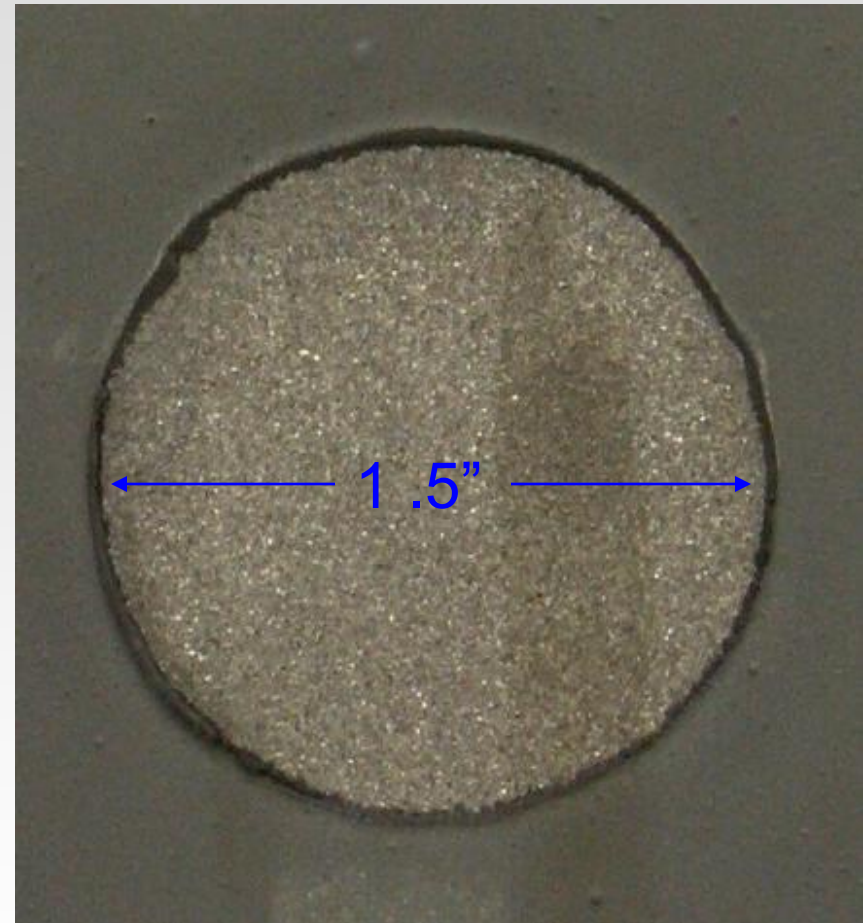


Fresh Water      Salt Water      Outdoor

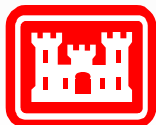


# Epoxy Primer

- **Bullet-Hole Testing** iaw AASHTO M-300
  - White metal blasted 1 ½ - inch diameter
  - Immersed in 5% Salt Water Solution
  - Demonstrates Cathodic Potential
  - Cathodic Throwing Power



500+ Hours



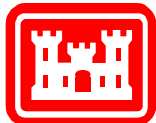


# Durability

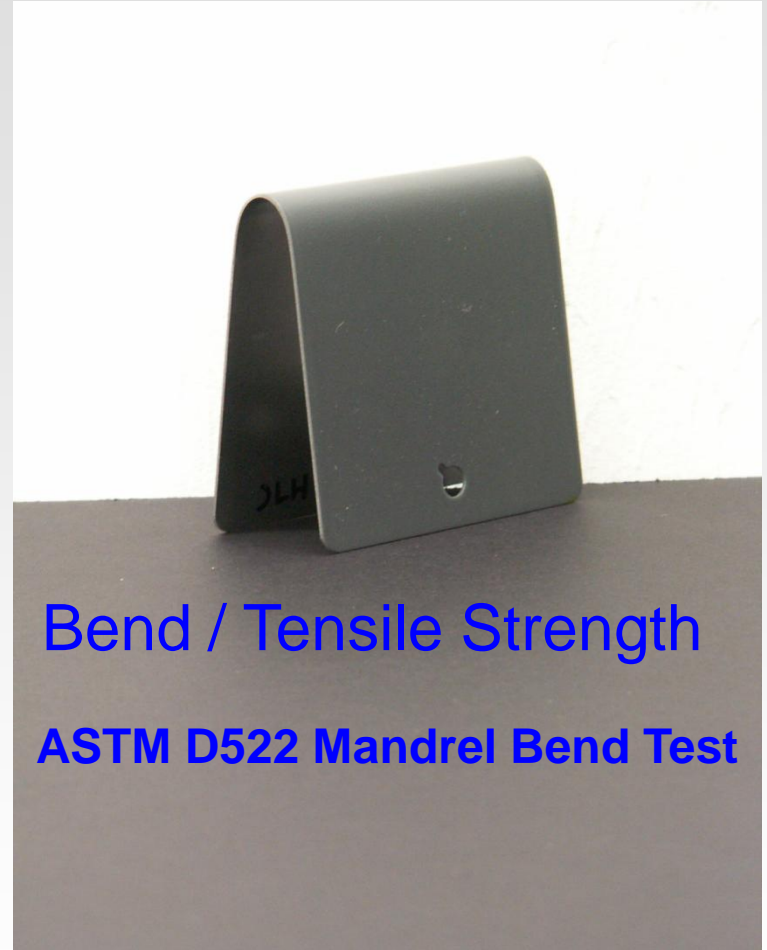
## Impact Resistance



**ASTM G14 Falling Weight**



**US Army Corps  
of Engineers**



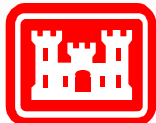
**Bend / Tensile Strength**

**ASTM D522 Mandrel Bend Test**

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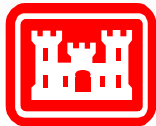
# Benefits

- Improved integrity of barrier films due to
  - lower pigment loading
  - SWNT reinforcement
- Improved durability and modulus under stress; impact, abrasion and flexing
- Cathodic corrosion protection in the event of a coating defect



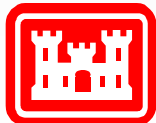
# Benefits (cont.)

- More resistant to heat and UV
- Weight reduction via
  - lower metal content
  - reduced film thickness
- Better aesthetics, color and gloss with lower loadings and ability to pigment
- Less vulnerable to pore, coating break, and other coating defects
- Less susceptible to poor adhesion due to inadequate surface preparation



# Benefits (cont.)

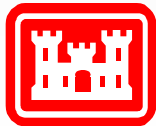
- 3- coat performance with a 2-coats
  - Structural integrity with lower metal loading
  - Eliminate intermediate coat build
  - Compatibility with high performance topcoat
- Reduction of film thickness
- Potential of single coat direct to metal system outperforming traditional 2 and 3 coat systems
- Longer service life
- Lower overall costs





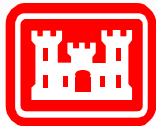
# Environmental Benefits

- Lower zinc and associated lead levels (approximately 50% reduction) with zinc system
- Total elimination of heavy metals using the aluminum system
- Easy to formulate high-solids coating systems
- Longer service life and waste reduction



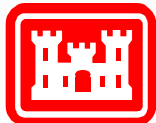
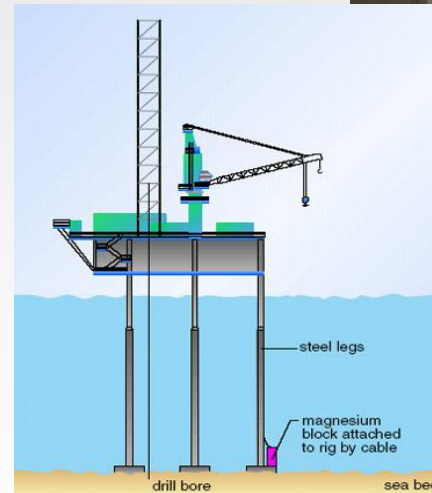
# Application Methods

- All conventional wet coating methods
  - Spraying
  - Brushing
  - Rolling
  - Coil coating
- Powder Coating (under development)



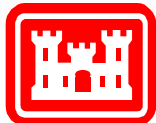
# Fields of Use

- Aerospace and Defense
  - Marine coatings
  - Lightweight performance coatings
  - Zinc-chromate alternative
  - Plating alternative
  - Steel hardware & structures
- Petrochemical Industry
  - Offshore rigs
  - Oil tankers
  - Pipelines / transmission lines
  - Drilling / refinery / plant maintenance coatings
- Locks & Dams



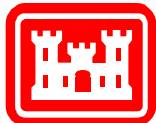
# Current Project

- Title: *“Inherently Conductive Additives for Reducing the Zinc Dust Content In Corrosion–Inhibiting Primers for Steel”*
- 3-Coat epoxy/polyurethane system applied December 2008 to a fuel tank at Ft. Bragg, NC
- Corrosion coupon test rack in place
- Coating and coupons will be monitored for 2 years +



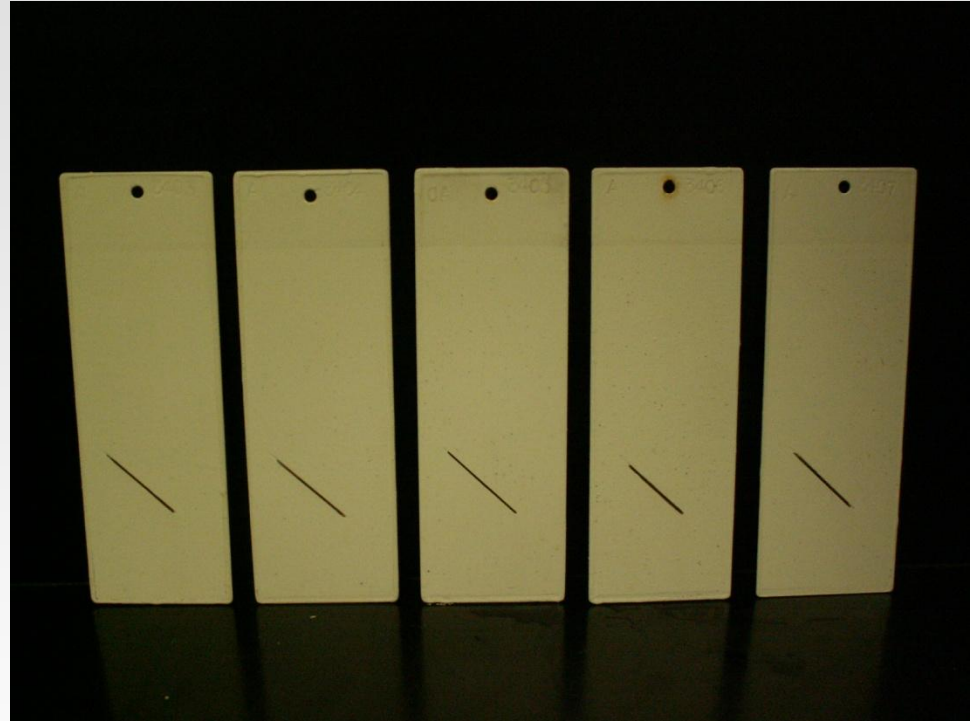
# Project Outcomes

- DOD Specification & Standard Development
- Implementation Army – wide
- Expand to other services



# Conclusion

- INNOVATIVE EPOXY/POLYURETHANE SYSTEM USING SWNT UNDER EVALUATION
- Characteristics
  - Toughness & durability
  - Corrosion protection
- Benefits vs. traditional system
  - Lower metal content
  - Lower pigment loading
  - Lower weight



# Contact Information

Susan A. Drozd

U.S. Army ERDC CERL

*P.O. Box 9005*

*Champaign, Illinois 61826*

*Phone: 217-373-6767*

*E-mail: [susan.a.drozd@us.army.mil](mailto:susan.a.drozd@us.army.mil)*

Todd Hawkins

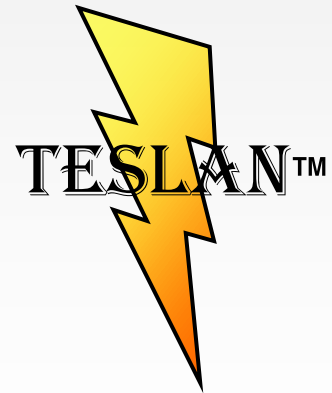
Tesla NanoCoatings Limited

*P.O. Box 270*

*Massillon, Ohio 44646*

*Phone: 330-880-5229*

*E-mail: [todd@teslanano.com](mailto:todd@teslanano.com)*



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